

## 이산화 탄소를 사용한 초임계 유체의 금속 세정

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### Effect of supercritical fluid on Aluminium cleaning using carbon dioxide

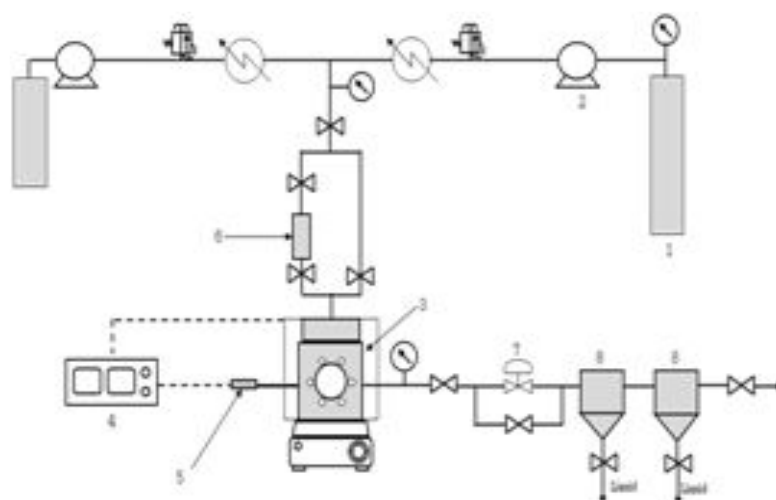
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#### 1. INTRODUCTION

Supercritical fluids have been widely used in extraction (Reverchon *et al.*, 1995, Della *et al.*, 1998), purification (Shishikura *et al.*, 1992), deposition (Watkins *et al.*, 1999) and cleaning processes (Williams, *et al.* 2003). Supercritical carbon dioxide(SCCO<sub>2</sub>) provides an simple method for cleaning metal substrates. SCCO<sub>2</sub> has the characteristics of both a liquid and a gas. It can dissolve solutes like a liquid and yet possesses low viscosity, high diffusivity and near zero surface tension. And it is easily accessible critical point (31.8°C and 73.8 bar) and simply tunable by changing the pressure and temperature, though specialized pressure cells, high pressure pumps, and other equipment are necessary for processing(Kendall *et al.*, 1999). The aim of the work is to illustrate the results obtained using carbon dioxide to clean metal substrates. Different process parameters were explored as operating pressure, temperature, cleaning time and co-solvent to test the process performance. In this paper, we were investigated the feasibility of using supercritical carbon dioxide to clean oils from metal parts.

#### 2. EXPERIMENTAL

The pressure, temperature and cleaning time conditions used in our testing were as follows: pressure (100, 125, 150, 175, 200 bar), temperature (40, 50, 60, 70, 80°C), cleaning time (3, 5, 10, 15, 20 min). These conditions were chosen because they could reasonably be used in an actual supercritical CO<sub>2</sub> cleaning process and comfortably exceed the critical point. There is one contaminant used in experiments: Gasoline oil. The metals chosen for cleaning experiments in this work is Aluminium(Al6061). The supercritical cleaning of metal substrates was performed in pure supercritical CO<sub>2</sub>, and in co-solvent system: Ethanol.



**Fig. 1.** Schematic drawing of the supercritical CO<sub>2</sub> cleaning system (1.CO<sub>2</sub>tank,2.Pump,3.Cleaningcell,4.Conrol-box,5.Thermocouple,6.Mixer,7.Backpressureregulator, 8. Separator)

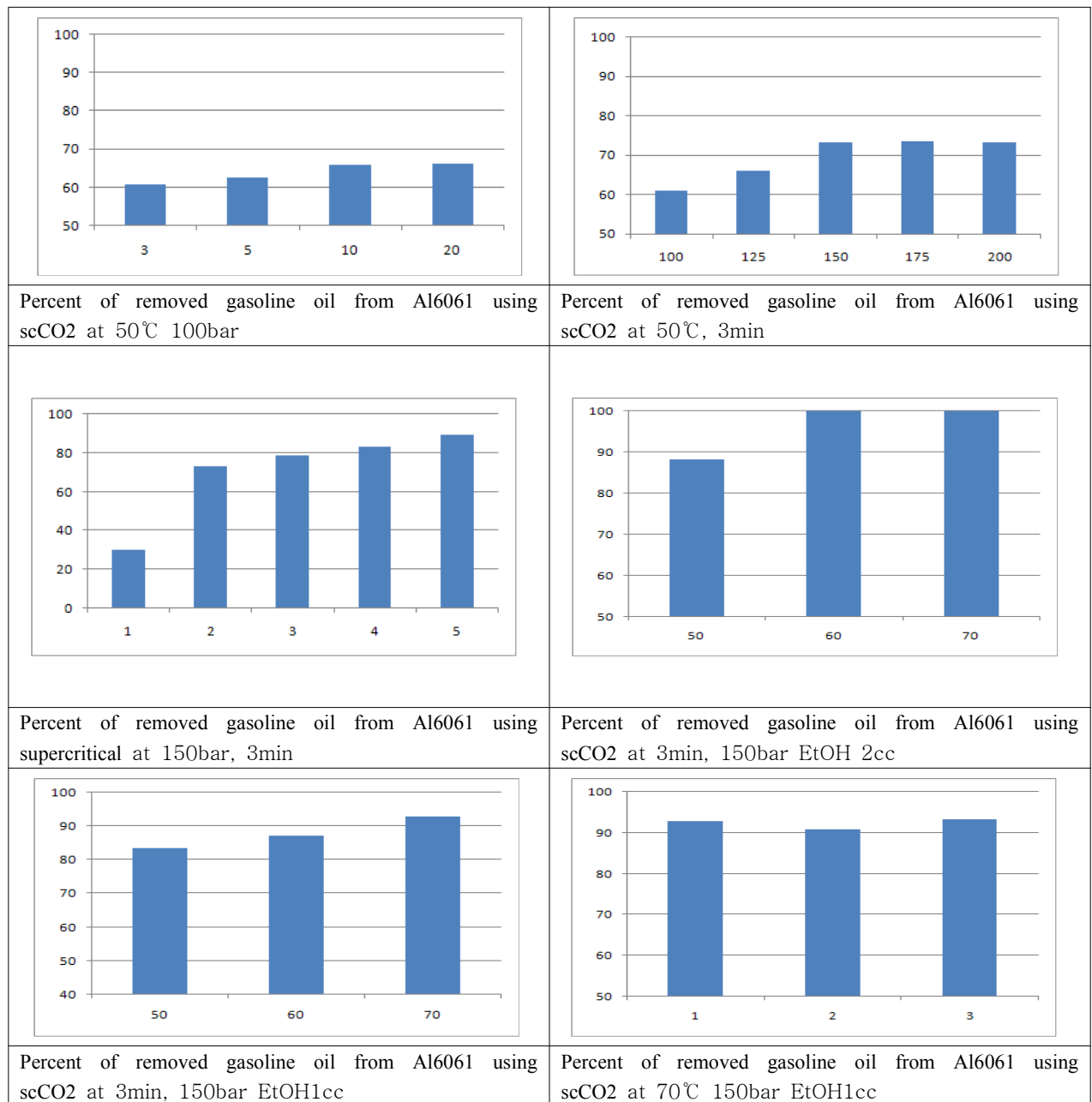
### Procedure

The typical CO<sub>2</sub> cleaning process is performed as a batch operation or a sasemi-continuous process using multiple cleaning vessels. Systems can be manually controlled or completely automated, requiring little or no operator attention during the cleaning cycle. The process schematic in Figure 1 illustrates the cleaning operation. Sample preparation was done prior to supercritical CO<sub>2</sub> cleaning. After measure the weight of pure samples, measuring the weight of contaminated samples that were contaminated by prepared each oils. Samples are loaded into the cleaning cell. The cleaning cell is then sealed using a closure mechanism designed for the operator sand working environment. The cleaning process begins by pumping liquid CO<sub>2</sub>, from a CO<sub>2</sub> storage tank into the cleaning cell and pressurizing the cleaning cell to operating conditions. At the end of the cleaning cycle, additional fresh CO<sub>2</sub> is pumped into the cleaning cell for 1minute, displacing the contaminated CO<sub>2</sub>, solvent in the reactor .As CO<sub>2</sub> exits the cleaning cell, it passes through a filter and then a pressure -reduction valve and vaporizes in the separator. Contaminants cleaned from the substrates are either filtered out of the system or collected in the separator. The percent of removed contaminants from samples were measured by the weight change between pure samples and contaminated samples.

### 3. RESULTS

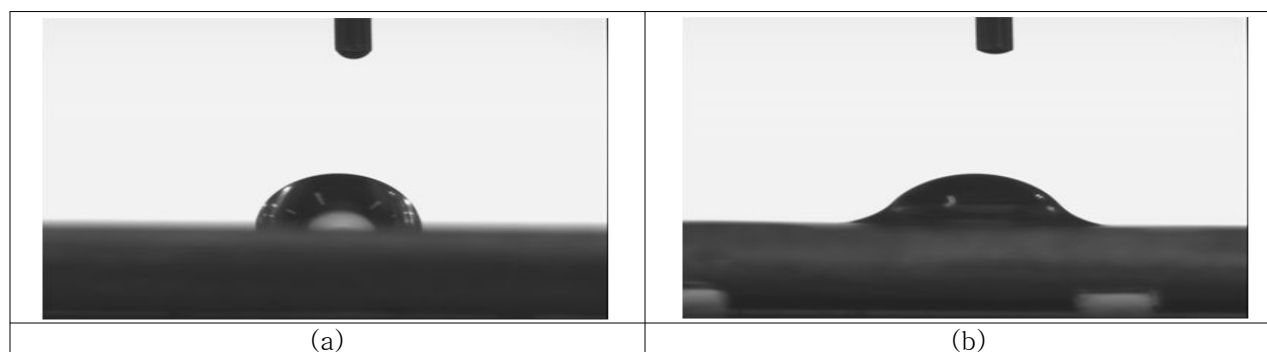
**Table 1** Optimal condition for contaminants removal using supercritical CO<sub>2</sub> and with co-solvent; ethanol

Metal substrates	Contaminants	Conditions
Gasoline oil	Al6061	70°C, 175bar, 5min,
Gasoline oil	Al6061	60°C, 150bar, 5min, Ethanol 2cc



**Fig. 2.** Graphs of percentage of removed contaminants from metal surface following to process conditions.

The percent of removed contaminants from trenches of metals using supercritical CO<sub>2</sub> and optimal conditions of each are shown as Table 1. The percent of removed Teflon lubricating oil from metals using supercritical CO<sub>2</sub> are shown as Figure 2,3. Mineral oil on Cu and Teflon lubricating oil on carbon steel were removed more than 80wt% as cleaning time is increased in supercritical CO<sub>2</sub> cleaning system. Even if the cleaning time was increased, couldn't remove oils perfectly from metals. This problem will be improved by adding co-solvent like ethanol.



**Fig. 3.** Results of contact angle measurement (a)after SCCO<sub>2</sub> cleaning process (b)before SCCO<sub>2</sub> cleaning process metal surface with contaminants.

The percent of removed from metals using supercritical CO<sub>2</sub> with ethanol and optimal conditions of each are shown as Table 2. Mineral oil was completely eliminated from metals in conditions of Table 2. Also the percent of removed Teflon lubricating oil from metals using supercritical CO<sub>2</sub> with ethanol and optimal conditions of each are shown as Figure 4,5. By using the ethanol as co-solvent, each conditions of system are improved.

#### 4. CONCLUSIONS

Supercritical carbon dioxide and co-solvents may potentially be used as cleaning media for removing contaminants from metal substrates. Mineral oil and Teflon lubricating oil completely removed by using supercritical CO<sub>2</sub> when ethanol is added to system as co-solvent. The Optimal data of our cleaning process is investigated.

#### 5. REFERENCES

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